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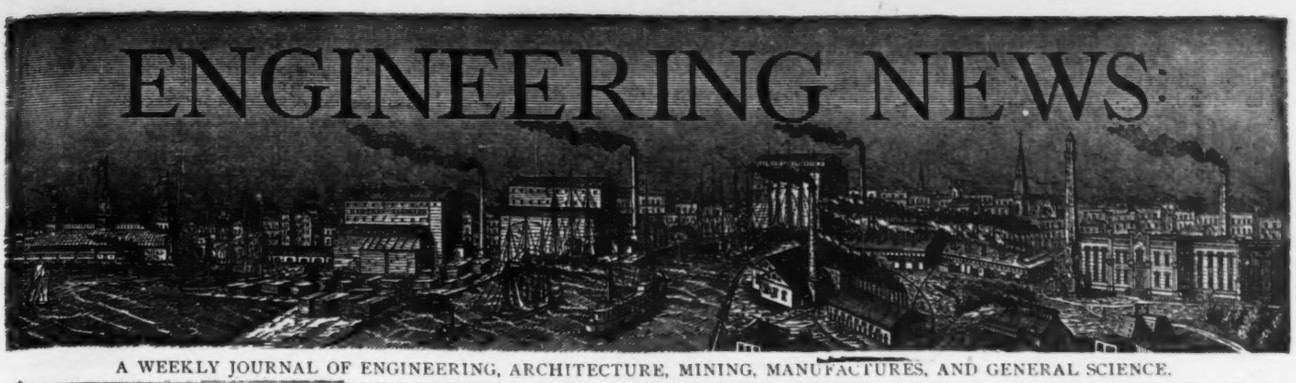

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HEAT AND LIGHT.

An Interesting Discovery—Prof. Crookes' Invention.

(From Boston Daily Advertiser.)

In a recent number of your paper there was a brief account of the remarkable discoveries of Mr. Crookes of London, which are thought by him to prove that a direct mechanical action is exerted by the sun's rays. One of the most beautiful results of this discovery is an instrument called by Mr. Crookes a "radiometer." It consists of a little wheel which revolves continuously under the action of the sun's rays, or, indeed, when exposed to the radiation from any other source of sufficient power. A glass cap, resting on a needle point, forms the center of the wheel, and to this cap are attached vanes of mica, coated with lamp black on the alternate sides. The wheel, with its needle point, is enclosed in a glass bulb two or three inches in diameter, from which the air is exhausted, as nearly as it can be, by means of the Sprengel pump.

The first instrument of this kind seen in Cambridge was very recently brought from London by Mr. N. D. C. Hodges of Salem, and it may be of interest to your readers to know that complete success has attended our efforts to reproduce the radiometer in this country. It is now made by Mr. Demuth, a skillful glass-blower, at Essex street, Cambridgeport, and is on sale by Mr. Joseph L. Bates of Boston, at whose store on Beacon street it can be seen; and the rapid rotation of its little wheel, completely isolated and protected against all the familiar sources of power, is one of the most remarkable sights that modern science has offered.

It can well be conceived that this new phenomenon has excited the greatest interest; but most, at least, of the physicists who have studied it do not agree with Mr. Crookes as to the cause of the motion. Experiments made at Cambridge abundantly prove that the motion of the wheel depends on the difference of temperature between the blackened surfaces of the mica and the surrounding glass.

It appears from these experiments that the rays of the sun, or any other source, are active in just the proportion that they are capable of raising the temperature of the blackened surfaces.

In the second place it has been found that the action of the rays on the blackened and bright surfaces of the vanes is not differential, as would be expected if the effect were in any way due to an impulse imparted by the rays; but there is a positive effect on the bright surfaces which is added to the greater effect on the blackened surfaces. The simple reason is, that the rays striking the bright surfaces in part penetrate the mica films, and add to the heat of the blackened surfaces on the opposite side. The wheel can be made to revolve by concentrating the light on the bright surfaces alone, or on both at the same time.

When the blackened surfaces of the vanes are heated by radiation above the temperature of the glass envelope, the wheel revolves as if the blackened surfaces were repelled. But—and this is the third point—when the glass is maintained at a higher temperature than the vanes,—their blackened surfaces meanwhile losing heat by radiation,—the wheel turns in the opposite direction, as if the bright surfaces of the vanes were repelled. This last experiment is easily made by inverting the radiometer so that the wheel cannot move, and heating the glass of the bulb against a lamp chimney until it feels hot to the hand. On then placing the instrument on its stand (in a place where it is not exposed to external radiation), the wheel will revolve as just described.

It would thus appear that the radiometer is a "heat engine," which although of a novel construction, is still a heat engine, that depends for its efficiency on the difference of temperature between its parts, precisely as in the well known example of the steam engine.

But, it will be asked, how does the heat act? We can only answer this question, as we should be obliged to answer a similar question about the steam engine, by reference to the theory of heat, and the conversion of heat into motion in the new phenomenon might have been predicated by the mechanical theory of heat, and is a beautiful confirmation of that theory which has become so well known through Professor Tyndal's lectures on "Heat as a Mode of Motion." According to this theory any gas (for example our air) is a system of small masses called molecules, moving freely in space until the direction of their motion is changed by collision with each other, or by striking some material surface; when, in either case, they rebound with the same or with a changed velocity. If they strike a heated surface they rebound with an increased velocity, while a cold surface produces the reverse effect. Familiarly, we should simply say that the air becomes heated or cooled by these surfaces; but according to one theory heat and cold are merely the effects of the changed velocity.

Now the air molecules in our radiometer, rebounding from the blackened surfaces, heated by radiation, spring back with a velocity greater than that with which they strike. Hence there must be a recoil, and it is this "kicking" of the molecules, like the "kicking" of a gun, which, according to our theory, causes the motion. Of course the molecules are also constantly rebounding from the bright surfaces of the mica vanes, but since the temperature of these surfaces may be regarded, essentially, as that of the confined air, the recoil nearly balances the blow, or at least the recoil is less than on the opposite surface. When, however, the interior air is heated, by heating the glass bulb as described above, then the blackened surfaces of the vanes—now losing heat by radiation as disproportionately as they gained it before—become the colder of the two sides, and the effect must, of course, be reversed. But if this be the explanation, why remove from the glass bulb the air which does the work; Why are these effects only obtained in a vacuum? The answer to these questions involves a much more abstruse point in the mechanical theory of heat than has ever before been brought to popular notice.

Although the molecules of the atmosphere move freely in all directions, yet in the dense air at the surface of the earth they are constantly hitting against each other, so that they only move, on a straight line, very minute distances before the direction of their motion is changed. and, what may seem surprising to those unacquainted with the details of the subject, we are able to calculate what we call the mean length of the free path of the air molecules under given conditions. It is obvious that the less dense the air, that is, the smaller the number of molecules in a given space, the greater must be the length of the mean path, and calculation shows that while in ordinary air the mean path is only a few millionths of an inch, in the highly rarified atmosphere left in the radiometer bulb it may become equal to the radius of the bulb so that the molecules may rebound between the glass and the vanes. Now, without entering into unsuitable details, it can be understood in general that the recoil of the molecules cannot produce its legitimate effect unless they really leave the surface of the vanes, and that this is not the case when the particles do not move more than a twentieth of the length of a wave of light before they are thrown back; and further, a mathematical analysis of the molecular motions shows that, although there is no common resultant where the mean molecular path is small, yet that when this ptah is commensurate with the size of the enclosure the molecules in their recoil concur to produce the motion we have described.

Of course if this theory is true there would be no motion in an actual vacuum, but, as every one must know, such a condition has never been realized, and, after experimenting on more than fifty of them, we know that in the bulbs of these radiometers one, at least, of every thousand molecules of the air which they normally contain is left. Hence, if we accept the estimate of Sir W. Thomson, that the number of molecules in a cubic inch of any gas, under ordinary conditions, is equal to 10^{22}, there will remain in the bulb of the radiometer of ten cubic inches capacity, exhausted to one one-thousandth, no less than a thousand million million million molecules of oxygen or nitrogen gas, and, as these molecules are moving with a velocity of from fifteen to sixteen hundred feet a second, we cannot call the space empty or the medium it contains motionless.

It should be stated that Mr. Crookes, in maintaining that the solar rays exert a direct mechanical action, relies for the support of his views on phenomena observed with different forms of apparatus which are far more delicate than the one here described. We have not had the opportunity of repeating these more refined experiments, and, therefore, would not be thought to imply that they may not have revealed facts which the present mechanical theory of heat cannot explain. We only express an opinion in regard to the so-called radiometer with which we have become familiar. All our experiments indicate that the very considerable motion of the little wheel of this instrument is as direct an effect of differences of temperature as is the motion of any heat engine. Still the name radiometer is not inappropriate, for the instrument is a most delicate measure of radiant energy, so far as the rays are capable of passing the glass envelope and of affecting the temperature of a blackened surface. Indeed, it is as delicate a measure of radiant heat, and, in many respects, a more convenient measure, than the famous thermopile of Melloni. Placed before a constant source of radiation, like a candle flame, the wheel of the instrument revolves with as much regularity as the second hand of a watch, and, as the distance of the flame was varied, the rapidity of the rotation varied according to the law of inverse squares, and the results were as sharp as a stop-watch, making quarter seconds, enabled us to time the revolutions.

With the delicate instrument we used, the heat of the hand placed a few inches off sensibly affected the time of rotation, and placed near the bulb doubled the rate; and although such a delicate force as this may be unable to start the motion of the wheel, it greatly modifies its velocity when revolving slowly and at a constant rate under the conditions just described. This indicates the best method of using the instrument as a measure of radiant energy, and it cannot fail to be of great use for this purpose, both in science and the arts.

Finally, while the explanation we have given in this article may remove from the very remarkable and important invention of Mr. Crookes some of the mystery with which it has been regarded, it really gives to it a greatly increased interest by opening a new chapter of molecular mechanics and pointing out a new means of measuring molecular magnitudes.

The Denver & Rio Grande Railroad, narrow gauge, has been recently opened for a distance of some 65 miles.

CONSTRUCTION OF A MASONRY DAM.

BY J. JAMES R. CROES. C. E.

From the Transactions of the American Society of Civil Engineers, New York.

[CONCLUDED.]

III. Mortar and Concrete.—The mortar made of one barrel of cement to two of sand, measured 9.70 cubic feet per batch. This was the average of a large number of measurements, the extremes varying 7 per cent. each way. While the void spaces of the stone averaged 47½ per cent., there would sometimes be a coarse run of stone which had 53 per cent. of void spaces. To cover such cases, the mortar had to be 54 per cent. of the bulk of the stone. This makes the charge of stone to a batch of mortar 18 cubic feet. The stone was measured in barrels, and at first 4½ barrels, holding 18 cubic feet, was the charge of stone. As it was found after some use of the barrels that they became coated with dust and screenings to such an extent as to considerably diminish their capacity, 5 barrels of stone (which held the proper quantity) was the charge for a batch of concrete.

For mixing concrete, platforms 12 by 15 feet, of 1¼ inch plank were used, the plank laid lengthwise in the direction the mixers used the shovel. Planed and matched plank are best, as causing less resistance to the shovel and less loss of water and cement.

The sand was wheeled or carted from the piles, deposited at one corner of the board, and 4 or 5 barrels of cement brought at a time and placed there also, the cart on its return trip taking away the empty barrels.

The sand and cement mixers, standing a barrel with both heads out on the corner of the platform, filled it with sand, which, with a twist of the barrel he spread, then opened and emptied a barrel of cement on it, and standing the sand barrel on the pile, filled it again. He then turned the mass over and heaped it in a conical pile.

The broken stone was deposited near the platform and washed in the pile by a hose. The stone man shoveled it into 5 barrels with handles and holes bored in the bottom, which stood in a row at the edge of the platform, and then poured over each from one to two buckets of water, which drained out through the holes in the bottom.

Four "mixers" cast the sand and cement from the prepared pile on the platform so as to form a basin into which from 7 to 10 bucketfulls of water were poured from a tub standing at one end of the platform which was kept constantly filled. As the water was put in, the mixers with the backs of their shovels spread the dry stuff over it, taking care not to let the water break through the ring, and mixed the mass by running their shovels through and turning them, thus making a bed of mortar about 8 by 5 feet and 3 inches thick. On this they emptied the barrels of stone, by upsetting them over the handles, and then scraped up the loose mortar around the edges, throwing it on top.

Then standing in pairs opposite to each other at the ends of the pile, they turned the mass outward by running the shovel under the stone and mortar, and turning it on its outer edge and drawing it back with a spreading motion over the turned mass. The opposite mixers worked in until the shovels met and then they returned to the edge again. When the two pairs met in the center of the board, the concrete was in two piles. The operation was then reversed, and the concrete turned again towards the center, leaving it in one pile, which was then shoveled into the hoisting box. In the meantime, the sand and stone men had been preparing their materials for the next batch, to which the mixers proceeded as before. The whole operation was performed in from 8 to 10 minutes. In 1869 a day's work for a gang of men was fixed at 50 batches of concrete. In 1870, 60 batches were given as a day's work, and the task was accomplished in from 8 to 9 hours, according to the length of travel of the cars, and consequent interval between the delivery of the boxes. The work was very arduous, and none but the most powerful men could stand it. They acquired great skill in the manipulation of the concrete and worked very systematically. Part of the time a fifth mixer was employed in turning up the edges of the pile and helping in the heavy shoveling into boxes.

During the first two years of the work, when the masonry was below or near the ground level, the mixers shoveled the concrete into barrows which they wheeled and dumped themselves. They were paid by the day, and no limit as to the amount was assigned them.

Two "rammers" took charge of the concrete as it was dumped from the barrows or cars, and spread it and then rammed it with wooden rammers.

In the following table is given the cost *in time* of laying concrete for each season separately, and also, for comparison, the cost of laying concrete at St. Louis, Mo., as furnished by Mr. T. A. Meysenburg, when in charge of the construction of a reservoir for the St. Louis Water Works. He explains the greater cost of mixing by saying that laborers will not do nearly the same amount of work in that latitude that they will at the East.

	N. Y. Storage Reservoir.				St. Louis Reservoir.		
	1867	1868	1869	1870	1867	1868	1869
Proportion of stone to mortar.	2.715	4.082	6.206	3.720	....	....	....
Cubic yards laid	1.65	1.85	1.85	1.85	2.5	2.0	....

To compare the four years' work, the hoisting must be left out of the account. In the first two years, the mixers did the same work that the mixers and car tenders together did in the last two years. The men handling sand and stone must be taken in connection with the carts as the transportation from the piles was done by barrows or carts, according to the distance from the mixing board. Calling a cart and driver equivalent to two men, we have, as day's work, per cubic yard:

Days' work per cubic yard.	Mixed on Level and wheeled in		Hoisted by Steam and run on cars		On Level Wheeled in.		
	From 27 to 10 feet below surface.	From 10 below to 6 feet above surface	From 6 to 28 feet above surface.	From 28 to 45 feet above surface.			
Mixers	0.223	0.227	0.145	0.121	0.603	0.537	0.399
Derrick and carmen.	.....	.....	0.088	0.070	.....	.....	.....
Engine—hours.	.....	.....	0.152	0.108	.....	.....	.....
Handling sand	.....	.....	0.065	0.071	.....	.....	.....
	0.161	0.114	.....	.....	0.183	0.134	0.250
Handling stone	.....	.....	0.127	0.098	.....	.....	.....
Carts	0.065	0.076	0.040	0.035	0.088	0.057	0.068
Ramming	0.125	0.078	0.071	0.073	0.125	0.107	0.128
Sand—cubic yards	0.428	0.416	0.420	0.420	0.373	0.411	0.444
Cement—barrels	1.446	1.420	1.425	1.428	1.259	1.394	1.500
Stone—cubic yard	0.888	0.946	0.946	0.946	0.920	0.826	1.111

	1867.	1868.	1869.	1870.
Furnishing material to mixers	0.291	0.266	0.281	0.229
Mixing and transporting to place	0.223	0.227	0.233	0.191
Total	0.514	0.493	0.514	0.420

This shows that the increased charge of stone, and the work coming nearer to the surface, diminished the cost in 1868, but that the change in 1869 to the system of paying for 50 batches as a day's work made a considerable increase in the cost for that year, while in 1870 when 60 batches was a day's work, the cost was similarly diminished. One reason for the diminished cost of engine in 1870 was that, when concrete had to be put in, two gangs of mixers were kept going by one engine on short runs of the car.

The spreading and ramming cost more the first season than afterwards, because, at the beginning of the work, the concrete was made much less moist than in the succeeding seasons, and the first layer on the rock in the bottom required the closest attention to obtain proper adhesion, and insure the bottom of the course being thoroughly filled with mortar. It was found afterwards that where the concrete was surrounded by large stones, freshly plastered, and the water was confined and prevented from running off, the mass worked better and more easily by being made quite wet. A batch transported from the mixing board to the place where it is to be laid, in one mass, and there dumped and spread to proper thickness (about 8 inches) makes far better and more homogeneous concrete than if moved in small quantities in barrows. There is less loss of mortar and water, less separation of the fine and coarse parts of the batch, and consequently, less tendency to have part of the concrete honeycombed. When the mortar is quite dry, hard ramming is necessary to consolidate the mass, but it also tends to disintegrate it the instant that the cement has begun to set, and this is generally before the mass can be thoroughly consolidated. The best method is to have the mortar a little more moist than is proper for masonry, the batch dumped in one mass, leveled off with shovels (the spreader at the same time turning over any irregularly mixed parts) and then slightly rammed with a wooden rammer. Where it comes against walls or forms it is better to compact it by cutting with a shovel and then slightly ramming, than by attempting to make it solid by ramming alone. The amount of water needed varies with the temperature and condition of the atmosphere. Ordinarily, when the sand is slightly damp, and the stone well washed and wet, the quantity of water used in mixing the mortar should not exceed 3¼ cubic feet per batch.

The concrete, when set, weighed 133¼ pounds per cubic foot; its specific gravity was 2.13.

IV. Setting Large Stone in Concrete.—The large unwrought stones laid in concrete, from the foundation to within 45 feet of the top of the dam, were set in full mortar beds, and the surfaces plastered just before concrete was laid around them. The setting was mostly done by laborers, one mason superintending. The cost in day's work per cubic yard was as follows:

	1867*	1868†
Total quantity laid—cubic yards	1,234	2,353
Percentage of whole mass	32	30.6
	Days, per cubic yd.	
Foreman (mason)	0.046	0.057
Laborers, setting	0.208	0.142
Laborers, plastering	0.085	0.086
Laborers, mixing mortar	0.078	0.053
Laborers at derrick	0.238	0.254
Cement-barrels	0.283	0.290
Sand—cubic yards	0.084	0.088
Stone—cubic yards	0.897	0.892
Transporting stone to the work—teams	0.100	0.073
Laborers loading—teams	.....	0.305

*Stone lowered average of 20 feet. †One-half lowered 5 feet; one-quarter swung in level; one-quarter hoisted 6 feet.

The cost of the mass of concrete and large stone, as laid in 1869, was 89½ per cent. of the cost of concrete, alone and in 1868 was 84½ per cent. of such cost.

For reasons before given the percentage of large stone in work of this class ought not to exceed 25 per cent. of the mass, in which case the cost of the mass may be safely estimated to be reduced 10 per cent. below concrete cost, and its specific gravity increased 8 per cent.

V. Cut Stone Masonry—Quarrying.—The stone for cutting was split out on the hillsides, and hauled to the stone yard near the dam. During the first year the quarry was not well managed, and the cost was too great to be of service for comparison. During the second year, the greater portion of the stone quarried was for rough stone and for breaking. The cost in time of quarrying the stone not intended for cutting was for 3,400 cubic yards:

Days per cubic yard		Days per cubic yard.	
Foreman	0.041	Tool-boy	0.035
Drillers	0.339	Teams	0.141
Laborers	0.140	Labor, loading teams	0.977
Blacksmith	0.036	Tools, powder and fuse to be added.	

From January, 1869, to July, 1870, 4,000 cubic yards of stone for cutting were quarried. All of this was split out with plugs and feathers, and hauled to the stone yard, an average distance of one mile. The cost in time was:

Days per cubic yard		Days per cubic yard.	
Foreman	0.114	Tool-boy	
Drillers	0.917	Teams	0.620
Laborers	0.429	Labor loading teams	0.284
Blacksmith	0.102		

VI. Stone Cutting.—Rubble range masonry is described above. The stone was estimated at 2½ feet beds. The actual average bed as laid in walls was 2.715 feet. As estimated, 10.8 square feet of face=1 cubic yard. The average face dimensions of the stone were 1.8 feet rise×3.6 feet long=6.48 square feet face per stone; this gave about 19 superficial feet of joint cutting per stone.

The average days' work of a man, deduced from 3¼ years' work, in which 5.200 cubic yards were cut, was 6.373 square feet face per day. That is, 1 cubic yard took 1.569 days' work of cutting. Average day's work of superficial feet of joint was 18.7 feet per day.

In cutting the granite for the gate houses of the Croton reservoir at 86th street in New York, in 1861–2, the minimum day's work for a cutter was fixed at 15 superficial feet of joint. This included also the cutting of a chisel draft around the face of the stone, which costs per linear foot about one-forth as much as a square foot of joint, making the actual limit equivalent to about 17.7 square feet of joint.

On the same work, the proportion to be added to the cost of cutters to give the total cost of stone yard was as follows, for 19 months' work:

For superintendence	add 8 per cent.
For sheds and tools	" 7 " "
For sharpening tools	" 11 " "
For labor moving stone in yard	" 10 " "
For drillers plugging off rough faces	" 4 " "
Total to be added	40 " "

For dimension stone, cut to ¼-inch joints, and hammer-dressed (pean hammered) on the faces, 1 cubic yard takes 9 days' work of cutters. The coping of the dam composed of two separate courses of stone,

1 of 12-inch rise, 30-inch bed, average length 3.5 feet.
1 of 24-inch rise, 48-inch bed, average length 2.5 feet.

top pean hammered, face rough with chisel draft around it, beds and joints to lay ¼ inch, took per cubic yard 6.1 days' work of cutters.

Grooved work for stop plank on upper face of the dam with fine cut grooves, courses averaging twenty inches rise, took 10.86 days'' work of cutters for every foot rise. Steps cut in rock to receive the face wall of dam on northeast end, took 1.3 days' work of cutters per linear foot of face. The above rates are all for granite, or stone of similar hardness.

The stone used for the dam averaged 172 pounds per cubic foot, and the specific gravity as laid in wall with mortar was 2.71.

VII. Laying Masonry.—Most of the cut stone was laid by one mason. More than two were not employed at any time. The mason's gang also shifted derricks. The cost of hauling stone to work varied with position of the blocks in the yard and whether they were assorted there into courses, or lay promiscuously.

The cost in time of laying the masonry in each year was as follows:

Cut Stone Masonry.. Total cubic yards laid	1868. 1070	1869. 2270		1870. 2530
	Hand hoist.	Hand hoist	Steam hoist.	Steam hoist.
Days per cubic yards	Av. 5 ft.	10 to 20 ft	20 to 30 ft	30 to 50 ft.
Mason	0.120	0.119	0.082	0.108
Laborers	0.184	0.188	0.145	0.155
Mortar mixer	0.100	0.082	0.070	0.101
Derrick and carmen.	0.327	0.341	0.235	0.261
Engine, hours	.....	.....	0.462	0.490
Cement, barrels	0.314	0.304		0.280
Sand, cubic yards	0.093	0.093		0.093
Stone, cubic yards	0.897	0.889		0.900
Teams from yard	0.100	0.096		0.110
Labor loading teams	0.184	0.223		0.086

The stones were suspended by two hooks at the ends of a chain, on which was a sliding ring. The hooks were put in notches on the front and back of the stone, made

with a stone cutter's "point." The sliding ring enabled the bed to be slung at any angle. The lower face wall was set with the beds sloping back 2 feet in 5. This inclination caused a good deal of trouble. A stone would rest without sliding when it was first laid on the mortar, but when struck with the maul would slide unless the blow was delivered perfectly square with the stone. This was almost impossible to do, and as a good purchase for a pinch bar could not well be obtained, the masons used blocking against the concrete to hold the stone in place. This had a tendency to throw the rear of the stone up and keep it from its bed. Although apparently a small matter and easily attended to, this is in fact a serious objection to the laying of stone on that slope, when, as in this work there are over 3 miles of stone to be so laid. It is better to diminish the face batter to one-third instead of four-tenths, even if it involved the making of an occasional offset in the wall to reduce the amount of material.

VIII. Brick Masonry.—The amount of brick masonry was small, only the arches of the waterways, and the interior walls of the gate house being laid in brick. The bricks used were "Croton" hard burned selected brick. The arches were semicircular, 4¼ feet in diameter, laid in three rings. The inner ring contained 33 brick, the middle 38 and the third 42. As laid in the arch, 22 stretchers, or 47 headers were 14.90 feet long. 1 cubic yard took 554 brick and 0.95 barrels of cement.

The sizes of brick vary so much in different localities that any estimate based on the number of brick laid has only a limited local value. The proportional number of brick used in different classes of work may be useful. Thus. 1,000 of the same kind of brick, viz.: "Croton hard brick," laid,

In lining wall of gate house substructure, 86th Street New York.....45.2 cu. ft.
In flat arch, High Bridge enlargement, New York...40.0 cu. ft.
In small arches, Storage Reservoir.....48.9 cu. ft.

On an average—the weight of these bricks is 4½ lbs. each, and they will absorb 19 per cent. of their bulk of water.

The time of masons laying brickwork under inspection varies very much from that in ordinary building. No class of mechanics needs more instruction at the outset, and constant supervision than bricklayers on public works.

In estimating on the cost of brickwork, the class of work must be particularly considered. The great difference in cost of different kinds of work is exemplified by the following table of actual cost:

	Days mason per cubic yard.
High bridge enlargement 1863. Lining wall and flat arch laid with very close joints.....	0.714
Washington aqueduct, 1864. Circular conduit 9 feet diameter, 12 inches thick.....	0.439
St. Louis water works. Conduit, semicircular arch 6 feet diameter, vertical sides and invert.....	0.364
Storage reservoir, 1869. Lining of gate house, walls and arch; rather rough work.....	0.304

Roads—Three miles of new roads around the reservoir were built by the department. The road bed is 16 feet wide with crown of 6 inches, and a ditch 1½ feet deep on the side. All material was removed to a depth of one foot below the grade, and a top dressing of the best gravelly earth in the vicinity, free from stones over 1½ inches in diameter put on and well carted over. Fillings were made with loose rock, and frequent culverts provided. On the reservoir side, retaining walls of boulders, topped with a fence wall 3½ feet high, 2 feet wide at the bottom and 18 inches at top, were built. These roads have been in use five years, have never been repaired and are perfectly good now. The cost of the road, fence walls and three bridges was $18,172 per mile.

The cost of the dam alone to the completion of the original design (except calking and pointing the upper face) in 1870, was $370,000. The total cost of the reservoir, including land, dam, roads and engineering to the same date was $590,000.

In preparing this memoir, an endeavor has been made to present only the results of actual experience, and to aid in supplying a want which is often felt by engineers in estimating the cost of work with the desails of which they are not familiar. Every engineer of experience has his collection of memoranda concerning work on which he has been engaged, but when called upon to estimate on another class of construction, data are very difficult to obtain. The estimates of contractors are too frequently based on mere guess-work, as is shown by the very great discrepancy in the bids on every work which is offered at public competition. The only data which can be relied upon are founded on observation of the time actually taken to perform certain operations. With these as a basis, the cost at current prices can be computed. To this cost must be added the amount needed for plant superintendence and profits, concerning which no rule can be given, as every public work has its peculiarities which require special study, but at the bottom of all is the actual cost of doing the work, and a knowledge of this is essential to making an intelligent estimate,

The use of Steam Carriages on the Street Railways and Common Roads.

(From the Journal of the Franklin Institute)

In none of the appliances of the steam engine, since it was emancipated from the patents and the practice of James Watt, in the year 1800, has so little accomplishment resulted from so much ingenuity and effort, as has been expended upon the use of steam as a means of transport in the ordinary avocations of life. The very earliest attempts at locomotion were made upon common roads, and so far as *movements on these* have been effected, the success attained nearly seventy years since by Trevithic has scarcely been equaled, and certainly has not been far surpassed down to the present time, notwithstanding the great advance in the knowledge of the properties of steam, and in the facilities for construction The essays have numbered by the hundreds. Experienced mechanics, with skilled labor applied in the direction of thorough knowledge of mechanism and of the steam engine, have vied with inventive projectors who have possessed that ignorance, which, untrammeled by *educated* notions to unlearn, sometimes gives scope to ingenuity and novelty; and both knowledge and invention have failed alike.

Within the past few years there has been put in use in England, as a means of hauling heavy weights, the form of engine known as a Traction Engine, and as the roads of that land are (and from the absence of frost can be) kept in excellent order, and as the quantity of heavy material to be removed is very great, these engines have increased, and continue to increase, in number. Another class of engine in England, but little known in the United States, the Agricultural Engine, which is a power engine of small size, with its boiler mounted on wheels, to be moved from place to place, has also been made to be self propelling. The road roller is another type of locomotive which has been quite fully introduced. None of these answer description of steam carriages, nor does the kind of engine likely to grow from them, promise much towards a Darwinian developement into what will eventually be found to be employed in transporting passengers and light loads in the street, whether on the rails or on the pavement.

The mechanical difficulties to the application of steam as a motive power for carriages, have gradually come to be appreciated, and with the somewhat more complete knowledge of the conditions and requirements, it is probable that the next attempts, made in earnest, by skilled and informed mechanics, will effect more satisfactory results. It is a settled conclusion that the adhesion of the wheels, or of a pair of them, sustaining half the load, is ample for the purpose of impulsion at any grade practicable for ordinary road use, only noticing that the contact or bearing of the drivers upon the ground must be positive and uniform. A four wheeled vehicle with axles attached to a rigid body, when standing or running on the uneven—generally twisted—surface of a road, will obviously rest or have its bearing only upon three of its wheels, and this condition of three points of bearing attaches to the tram road locomotive, as well as to the common road one. Balance bars or gimbal-hung swinging axles will secure the equal distribution of weight upon drivers, or what in the road carriage is equally essential, on directing wheels. The possibility of *driving* around any curve, as the directing wheels may lead or trail, is secured by the "jack-in-the-box motion" of the traction engine, which applies the force to either driver of a pair of wheels, imparting to either wheel in whatever proportion is requisite, the motion or rotation it should have when running upon a curved line. Of course, the abrading action of the tires (like that of the faces of a mortar mill) upon the ground, yet remains, and the wear on them, and on the road bed at the place of turning, will still be large, but the leverage to overcome this grinding, and the amount of grinding, will be so much less, than that which accompanied the action of wheels rigidly attached to an axis, that it can be surmounted or endured. The conditions of leading the tram road carriage around the curve differ altogether from those of guiding the ordinary road carriage. The tram road carriage will guide itself, with either the Bissel two wheel truck, or, more perfectly still, with the old German six wheeled wagon arrangement, (in which the axles adjust themselves radially to any line of curvature); while the ordinary road carriage must have the swinging axle only for a guide.

In the application of power to the steam carriage, it is apparent that the starting resistance is the most difficult to overcome; and, although many methods suggest themselves, none has yet had practical application in service in parallel work. The utilization of the momentum of stopping *may* be available to help the starting of a carriage. This has already been elucidated as possible on railway trains, but in this case the gain from from all the momentum lost at a stoppage bears so small a porportion to the labor of the locomotive engine, as not to be worth saving. The necessity of two speeds, at least, is acknowledged, but with the gearing of the jack-in-the-box there is no great objection to double speed wheels in addition. The total motive power of the engine demanded is about what is rated two horse power, at the most, and the engine becomes very small. The success of the "three cylinder engine," now made by the thousand, almost, in England, and its facility for the use of the expensive force of steam, at high velocities, seems to open a ray of light into the darkness where the steam carriage of the future now lays. The recognition of the fact that the interstices of a mass of coal, on a given surface, present an equal area for any size of lump, whether coarse (large) or fine, only that all the lumps or grains must be sorted to the same size, is slowly being made; and as our fine anthracite coal, of *pea* size runs like water, it follows that automatic firing of the small boiler will be the finality for the purpose of the steam carriage (as well as the possible finality of the firing of marine, if not all, steam boilers) This, with suitable automatic arrangement for feeding, will permit the steam carriage to be run by one man alone. Only some of the salient points of the mechanism of the coming carriage have been noticed here; others of nearly equal importance present themselves, which can be discussed or settled, in the same way, by those especially interested.

Eventually, the steam carriage will be as distinctive as the locomotive engine, and will have its nationalities as the locomotive has, and its individuality, as the American locomotive of to-day has Wm. Mason inscribed upon it.

The steam carriage when in use on the public highways or tram tracks, will be much more safe from accident of any kind than the ordinary vehicle or the street car. The requirement of penalty can be made as stringent as letting all statute laws out of the question will allow the enforcement of common laws; and under the impulse of such penalties—safeguards, catchers, detentors, or arresters—automatic contrivancies of all kinds, will multiply to the point that will give security to the other traffic, quite as great as that now attendant upon the average driver and the carriage horses. While the control of the apparatus, either to start or to stop, *can* be made certainly as effective as the present ordinary carriage, however carefully driven.

The abuse of animals (horses) in our street cars is a shocking evil, and those instincts of humanity which lead us to avoid the occasions or exhibitions of cruelty, now urge with great strength the substitution of inanimate force for so completely mechanical exertion of power. The repairs and restoration of the roadways, consequent upon the employment of horses in so large numbers, form the chief items of expense to the highway department, and the substitution of steam carriages would materially reduce this burden on the city. The removal of the horses from the street railroads alone, would greatly improve the cleanliness of streets, by the prevention of so much decomposable matter now deposited upon the surface of the pavement, to be ground under the wheels to an impalpable powder, blown about with the winds, and vitiate the very air we breathe, With due regard for the public health alone, it is desirable to substitute the steam carriage for the horse car.

Ship Resistance.

From the Galaxy.

After an exhaustive inquiry into the laws which govern the flow of water in the presence of obstructions, which was presented to the British Association, Mr. Froude finished by an analysis of the resistances which a ship has to overcome. These are three in number: surface friction, friction of the particles against each other, which is only felt practically when the ship has features sufficiently abrupt to cause eddies, and finally wave genesis. The old idea that there is a direct "head resistance" proportioned to the largest immersed area of the vessel he entirely rejects. There is no force due to the inertia of the water on the area of the ship's way, With large ships surface friction is the largest item. In the Greyhound, a bluff ship of 1,100 tons, 170 feet long, with a thick stem and stern posts, making large waves at ten knots an hour, this surface friction was 58 per cent. of force to overcome. In the long iron ships of the modern merchant steamers it is greater still. Eddy resistance hardly has any value with such fine lines as are now used.

Wave resistance is important, and the laws of such wave combinations are so complex that it is impossible to predict what waves will be formed by a given vessel. Mr. Froude says:

"There are, however, some rules, I will not call them principles, which have to some extent been confirmed by experiment. At a speed dependent on her length and form, a ship makes a very large wave resistance, at a speed not much lower than this, the wave resistance is considerably less, and at low speed it is insignificant.

"Lengthening the entrance and run of a ship tends to decrease the wave resistance; and it is better to have no parallel middle body, but to devote the entire length of the ship to the entrance and run, though in this case it be necessary to increase the midship section in order to get the same displacement in a given length. With a ship thus formed, with fair water-lines from end to end, the speed at which wave resistance is accumulating most rapidly is the speed of an ocean wave, the length of which from crest to crest, is about that of the ship from end to end.

"In order to reduce wave resistance we should make the ship very long. On the other hand, to reduce the surface friction we should make her comparatively short, so as to diminish the area of wetted skin. Thus, as commonly happens in such problems, we are endeavoring to reconcile conflicting methods of improvement; and to work out the problem in any given case, we require to know actual quantities." These quantities he hopes to ascertain from experiments he is now making. It will be seen from these criticisms that modern shipbuilding does not answer the theoretical requirements. Merchant steamers have the long straight "middle body" which Mr. Foude condemns.

Perhaps the fact that this increases the friction and therefore the cost of driving the vessel will bring about a reform.

The workingmen of Fort Wayne, Indiana, have held an indignation meeting and resolved against building water works in that city.

ENGINEERING NEWS.

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TECHNICAL EDUCATION.

A paper was read in June, 1874, before the American Society of Civil Engineers, by Thos. C. Clarke, upon the education of engineers, and it was followed by an interesting discussion. The course here advocated was first, a few years in college, the student being engaged with the ancient and modern languages, a moderate amount of mathematics, and the natural sciences; next, practice in the field and office, to gain an experience of how things are done ; and finally the technical school, where one should pursue a special branch selected previously. The writer sums up as follows:—"Let the earlier studies tend towards developing the mind of the student, strengthening his powers of observation and judgment, and teaching him to generalize. Then let him go into the field and study actual practice, select his special branch, and aquire the technical scientific knowledge necessary to the practice of that branch. Let him learn general principles in the schools and technical knowledge while in practice.

From the other side of the water we have a lecture delivered at the University College, October 5, 1875, by Prof. Alex. W. B. Kennedy, C. E., reported in *Engineering*, Oct. 8th and 15th, 1875, upon the place of colleges in engineering training. He includes in college what is also called a technical school. His ideas may be briefly stated thus:—The lines which the education should take would be, first, a general scientific groundwork, a knowledge of the principles of the sciences upon which engineering is based, mathematics in the various branches, physics, in the most general sense, chemistry, metallurgy and geology ; secondly, a knowledge of the way in which they are applied to engineering work, and an establishment of the identity of *theory* and *practice* ;—and lastly, not only the knowledge of these applications of the pure sciences, but also some experience in the applications themselves, that is, some practice in the constructive and other processes of which he has already studied the principles. The preliminary training would then be complete and the student could take up a specialty to advantage. This practice would be had in what might be called a physical laboratory, where the student should have access to a boiler and engine, should take part in experiments upon the strength and elasticity of materials, experiments in hydraulics, construction and testing of models, etc.

And now, later, we have the address delivered before the American Institute of Mining Engineers, by the President, Mr. A. L. Holley, Feb. 22, 1876, on the subject of technical education. This able address was reported at length in the *Engineering and Mining Journal*. He objects to workshops on a small scale and merely imitative, and would put the actual practice first and theoretical study later. His desire is to train *experts*. He says: "In order that the technical school should be in the highest degree useful, fruitful and economical, it must instruct not *men* of good general education, but *artisans* of good general education. The art must precede the science. The man must first feel the necessity, and know the directions of a larger knowledge, and then he will master it through and through." He would establish organized schools in the various existing engineering works, where they shall do good and full work during specified hours, under the discipline as well as the technical guidance of a master. "Young men, of more advanced general culture, when they begin the business of technical education, shall apply to nature first and to the school master afterwards."

Even if the reader does not agree with any one of the above writers on all points, he will find much food for reflection in the papers to which we have referred. Technical schools have increased in numbers and in the aggregate of attendance upon them, very rapidly within the past few years, and it is exceedingly desirable that the outlay should be well directed and confer the most benefit. What then should technical schools aim to do, and at what stage should they take and send out their students?

There is one thing in which all the above articles concur, the value and desirability of a good preliminary education, or as it is often styled, a liberal education. It is well-known to all who have had facilities for observation that the previous training of a college course, enables the graduate to progress more easily and rapidly in technical studies, and to master more readily the essential points of actual operations. The drill and discipline of the study of the dead languages and of the mathematics tell here, in having taught the student how to learn, and in having strengthened the power for close application and continuous effort. But habits of study in any direction are equally useful, and the more extended preliminary training of this sort the student may have the better. Engineering is so intimately linked with other arts and sciences that, in a practical point of view, there is no knowledge but what at some time, in an engineer's varied duties, may come of use. As most of the students in our technical schools are not young men of a previous extended culture it becomes necessary to occupy a large portion of the first years of the course with branches which are preparatory, general in scope, and not strictly technical.

While it is in the power of professional schools to recommend, it is hardly expedient for them to require a previous college course of study. The man of ample training can commence at an advanced stage of the curriculum, while those students of more limited knowledge, graduates of high schools and academies, will spend some two years in broadening their view and strengthening their powers. And here our schools show to advantage in comparison with those of law and medicine, in not being restricted to purely technical branches, and in taking some care that the students have an acquaintance with subjects not strictly essential to the professional work.

As to the preliminary education then, all seem to be agreed that it should be as broad, deep and thorough as possible. We must postpone until next week what we have to say on other points.

THE VILLAGE ENGINEERSHIP OF HYDE PARK.

A few weeks ago we took occasion to refer to the office of Village Engineer of Hyde Park in connection with the election for Trustees of that broad village. The election came off on Tuesday last and the ticket which we advocated was triumphantly elected. We congratulate the tax-payers of Hyde Park on their victory, and hope that "bummerism" in this, the most flourishing of Chicago's suburbs is squelched forever.

Owing to the rapid enhancement of Hyde Park real estate and its settlement mostly by a wealthy class, the question of sanitary improvements is now an important one and it becomes necessary for the newly elected Trustees to be careful in their selection of an engineer. As was shown by the figures in our last article, the expenses connected with the office during the past year were simply absurd, when the work done is considered, and the Trustees can find an engineer who can do all that is wanted, and do it well, for a great deal less than has heretofore been paid. In connection with the office we beg leave, with all due deference to the acknowledged reputation for business sagacity, of the Trustees elect, to recommend the name of C. McLennan, C. E., now a resident and large property owner in Hyde Park. We have had an intimate personal and professional acquaintance with him for about seventeen years (at which time he graduated with distinguished honors from the class of engineering in an eastern University), and we can vouch for his scientific and practical knowledge of the engineering problems that may be brought before him as Village Engineer of Hyde Park, and his character as an industrious, painstaking and thoroughly conscientious and honest engineer is too well known in Hyde Park and Chicago to need any further endorsement. Of the candidates for the office whose names we have had mentioned to us, we are confident that, in pursuance of their expressed policy of getting the fittest man to serve the interests of the village at a fair compensation, the one whose name we propose is by all odds the most worthy.

THE NAUTRICON.

And Sumner's Method for Determining a Ship's Position.

BY BERNARD R. GREENE, C. E.

(Written for Engineering News.)

This word, though not familiar, is doubtless destined soon to become so amongst navigators, as it is the title of a new nautical instrument recently patented by Rev. Dr. Thomas Hill, the wel known mathematician, ex-President of Harvard University, and now of Portland, Maine.

It is intended as a companion to the sextant and chronometer, and is designed chiefly to ensure the rapid and accurate determination of a ship's position at sea by Capt. Thomas H. Sumner's method, now extensively used. As the beauty of both the method and the instrument have won the admiration of the writer, it was thought that a sketch of them in the columns of the NEWS might prove interesting to many engineers, who, though not expecting to be immediately called upon to survey a trail upon the trackless ocean, are always ready to listen to an explanation of any new short cut to the solution of a problem, that will eliminate all appreciable errors.

Generally when the latitude is not correctly known, the longitude by chronometer will necessarily be in error, but the Sumner method furnishes the means, when the chronometer has correct Greenwich time, of ascertaining the ship's position, as a point can be determined by the intersection of two straight lines upon a Mercator chart. Observations can be taken at any time of the day or night, when an opening in the clouds reveals a known and favorably situated heavenly body, and the horizon is not too much obscured. The method depends upon the determination of one or two circles of equal altitudes of the sun (or other heavenly body) which are circles upon the earth's surface whose centers lie in a line joining the center of the earth with the sun, or, in other words, they are like the circles of latitude, their poles being the points upon the earth's surface at which, at the time of observation, the sun is vertical. This system of circles changes with the diurnal revolution of the earth and the declination of the sun.

As the ship from which an altitude observation is taken will be somewhere upon one of these circles, it is evident that if two circles are determined at such an interval of time as will allow the sun a sufficient change of azimuth, their intersection upon the surface of the globe will be her true place if she has not moved during the interval. If she has moved, then the bearing and distance by dead reckoning of her last from her first position is to be laid off from any point of the first circle and through the point thus found a circle of the earth drawn parallel to the first circle will intersect the second at her last position. Completing the spherical parallelogram by a line from the last point, her first position is found upon the first circle.

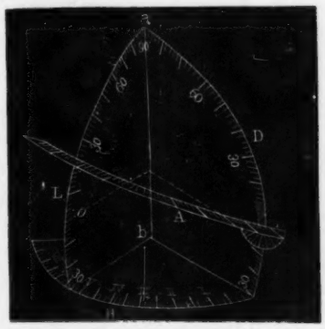
A circle of equal altitudes is ordinarily determined as follows: As, by dead reckoning, the navigator always has an approximate knowledge of his latitude, he now assumes it to be, say, 30′ greater, takes the altitude of the sun by the sextant, its declination from the Nautical Almanac, Greenwich time from the chronometer, and works up his longitude. The position thus obtained is projected upon a Mercator chart. Next, assuming a lat-

itude 1°, more or less, smaller than before, the other data remaining the same, he works up a new longitude, and projects a second point upon the chart. As the same altitude was used it is evident that these two points lie in a circle of equal altitudes, which, within limits of two or three degrees, will be practically a straight line. Therefore, through the two points upon the chart is drawn a straight line, upon which the ship must be somewhere. The bearing of any land intersected by the prolongation of this line is at once found, while both bearing and distance to any shore lying parallel and opposite to it are also found. After a sufficient lapse of time, say one to three hours, a second altitude is obtained, and, with the same assumed latitudes, two other points are projected upon the chart and a second line containing the ship's position is drawn.

These computations include four separate though similar problems, many searchings in tables of logarithms and corrections; and involve so much ciphering as to be therefore liable to error, especially at the hands of men of moderate skill in calculation.

Suppose now that it is desired to correct the compass. Either of the two lines plotted upon the chart being practically perpendicular do the direction of the sun at the time of the corresponding observation, it is evident that if the *compass* bearing of the sun had been taken at the same time it could now be compared with the *true* bearing of the line on the chart, by making allowance for the difference of 90°.

The nautrigon, as shown in the figure, consists in principle of four arcs of circles. D, the declination arc;



L, the latitude arc; H, the lower arc; and A, the altitude arc. D, L and A represent arcs of great circles of the earth, the first two being meridians, while H is an arc of a parallel of south latitude, placed in this instrument at 30°. This combination is, in short, a skeleton of less than one-third of a globe. The planes of D and L are hinged on the line *a b* representing the earth's axis, *a* being the north pole, while the plane of D is permanently attached perpendicular to the plane of H, leaving L free to revolve over it.

D is provided with a vernier carrying at its zero a short projecting pin which always points to the zenith, while A is detached and provided at one extremity with a half compass card whose center is a hole fitting nicely over the vernier pin. D and L are each 120°, graduated from the equator 90° north and 30° south; A is 90°, graduated with the 90° mark at the compass; and H is 120° divided into eight hours with subdivisions for minutes and seconds.

Now let us see what assistance may be rendered by the nautrigon in the above computations. Take the altitude of the sun simultaneously with the time by chronometer. Apply to the altitude the tabular corrections for sun's semi-diameter, dip of the horizon, refraction and parallax, the joint effect of which is usually given in one table and may be applied as a single correction. Set and clamp the vernier at the declination of the sun taken from the nautical almanac, thus bringiug the pin directly under the sun, the declination arc representing the sun's meridian at the time of observation. Attach the altitude arc to the vernier pin, and swing both this and the latitude arc to intersect each other respectively at the assumed latitude and corrected altitude. The latitude arc then stands upon the hour arc at the exact number of hours and minutes before or after noon when the observation was taken. This reading, corrected for mean time as usual, compared with the chronometer time, and 15° of longitude allowed for each degree of the difference, gives the longitude corresponding to the assumed latitude. Assume a second latitude, a degree or so lower than the first, swing the altitude and latitude arcs to intersect, read off the time as before and get the second longitude. Two points are now determined, in a line passing through the ship, which may be projected upon the chart.

As two or three subtractions and multiplications with small numbers constitute the ciphering for each position, much of which may be done mentally, it would seem that, until there is established upon the ocean highway a better system of guide boards than now exists in the sun and stars, the operations for finding a ship's position will never be simpler than these.

By means of the half compass card of the nautrigon the compass variation is readily obtained. For, having taken the compass bearing of the sun at the time, say, of the first observation, arcs A and L are now set to intersect at the *true* bearing of the sun read upon the compass card.

In south latitudes this instrument is to be imagined as inverted, the north pole becoming the south pole.

Although its design was suggested by the Sumner method the utility of the nautrigon is not thus limited. It will save a large amount of computation in great circle sailing, when the course to be steered at the several verifications of position may be at once read off the compass card without calculation. It is also useful in the solution of any problem involving a spherical triangle. Tests with a completed instrument have given most satafactory results.

The Sny Levee Disaster.

The washing out of the reservoir dam at Worcester, and the inundation and damage consequent therefrom, are outdone this week by the immense "crevasse" in the Sny Levee near Hannibal, Mo., where, instead of the letting out of the penned up waters of a little brook, a portion of the swollen volume of the mighty Father of Waters is being turned upon a vast area of country to drive hundreds from their homes and to carry ruin and desolation in its course Of the particulars of the disaster our readers will be fully informed by the city dailies and local newspapers, before our journal reaches them; we think, however, that the public will be interested in learning something about the levee that has been broken through. We reproduce, therefore, from Volume I, of this journal a portion of a paper on the subject of "Leveeing on the Upper Mississippi," by E. L. Corthell, Chief Engineer of the Sny Levee, and now Asst. Eng. South Pass Jetty Works, read before the Civil Engineers' Club of the Northwest, in 1874. Mr. Corthell writing July 10th, 1874, says:

Leveeing in the South has been for many years the most important of all public works, and the proper maintenance of the levees is the life of the people.

Leveeing overflowed lands has not been attempted till recently, to any considerable extent, on the Upper Mississippi.

It remained for a few enterprising farmers residing on a district known as the Sny Island, in Pike County, Illinois, to be the first who dared to attempt such a work.

This tract commences about twelve miles below Quincy, and extends down the river fifty-one miles.

Whether the river was once a vast lake with a waterline one hundred and fifty feet above its present high-water mark; flooded the whole country east to Indiana and north to the Great Lakes, or whether it was once a deeper, wider and more rapid river, free from its sandy bed and flowing without obstruction over the rock now found one hundred and fifty feet below the present low-water mark, and in a subsequent age deposited the sand and spread out this tract of land which we are now leveeing, are questions more curious than important.

As we find it, it is a river with a bed of sharp, clean sand to the rock. It has a velocity of from two to four and a half miles an hour, a difference between high and low water of from twenty to twenty-two feet, waters comparatively clear, its changes slow, its curves easy, and its position nearly permanent from year to year. On the west it follows the line of the bluffs; on the east it flows along a rich tract of alluvial land six or seven miles wide, the soil of which consists of a black sandy loam from three to ten feet deep. The plane of the tract at the upper end is ten feet below high-water mark, and at the lower end about eight feet below the same level. In this respect it follows the law governing the formation of sand beds, which are always higher comparatively at the lower end.

The district is divided its entire length by a slough or bayou about four hundred feet wide, which is generally parallel to the river, but now and then finds its way to the bluffs on the east, and then turning comes nearly to the river on the west. Connecting it occasionally with the river are cut-offs, which act as outlets or inlets according to the comparative heights of the bayou and the river From the peculiar meandering nature of this bayou it received the name of "The Chenal Ecarte"—the lost channel—which has been abreviated in common parlance into "The Sny."

The river, like all streams that carry sediment in solution, deposits the larger portion of its burden on its immediate banks in times of flood, and thus builds. as it were, in part, its own barrier to the lands lying remote from its banks.

This formation makes a water shed from the river toward the Sny.

The river breaks through this natural ridge occasionally, causing deep sloughs and cuts through which the river pours its overcharge before the banks are submerged. The water thus escaping from the river finds it way into the back country, and finally to the Sny, and is poured into the river again many miles below at the mouth of the Sny.

The Sny also receives the rainfall of the bluffs and high lands for many miles back by means of several creeks, which, rushing down through the breaks in the hills, go meandering across the district till they unite with the Sny.

Along the banks of these creeks, as well as along the Sny, its various tributary sloughs and the river, considerable timber is found of the character usually seen on alluvial tracts.

The waters in the low grounds, sloughs and ponds rises and falls with the river.

When the river is low, the whole district is dry, except in the deepest sloughs and in the Sny. As the river rises, the water gradually shows itself coming up in the low places near the river and the Sny, keeping below the level of the river but rising as long as the river rises.

In digging wells at any season of the year in any part of the district the water will be found near the level of the water in the river. When the river is nearly ready to overflow its banks and the current is rapid, there can be seen a perceptible flow in the ponds from south to north.

The district lies in one of the most valuable and best farmed countries of the state, the market value of whose lands in the vicinity of the district is from seventy-five to one hundred dollars per acre.

Across the river on the Missouri side are Hannibal, Louisiana and Clarksville. Three railroads pass through the district and two bridges connect it with Missouri. The value in the market of the land in the levee district before the levee was commenced varied from three to thirty dollars per acre, much the larger portion being near the smaller figure.

The valuable character of the land surrounding. and the expectation that the overflowed lands would increase rapidly in value with the levee completed, made it very important that great care should be taken in assessing the taxes which were to be levied upon the tract to pay for the co struction of the work.

The plan for the construction of the embankment was made after a careful examination of the material along the line of the work, to ascertain the angle of repose of the slope, when wet and dry. The recorded history of similar works in this and other countries was searched with care. We put ourself in communication with experienced hydraulic and levee engineers, and also made a personal examination of the levees and levee districts in Mississippi, Arkansas and Louisiana and conversed with engineers and others in the South, who had gained extensive practical experience in constructing and maintaining levees.

The examination resulted in the adoption of the following general specifications, which have proved themselves eminently fitted for levee work in this locality.

The ground under the embankment to be cleared of all perishable matter, and the whole surface ploughed up in lines parallel to the center line of the levee, to give a bond between the original surface and the new bank. A ditch about three feet wide, and as deep, to be dug along the centre-line of the levee to cut off any communication there might be under the bank by means of decayed roots or logs. All trees within falling distance of the crown to be cut down. All stumps to be grubbed one foot deep for a distance of 15 feet, measured from the outside slope stake toward the center line, this precaution being taken to prevent any stumps protruding through the flat outside slope—a neglect to do this having caused several crevasses in the South. The stumps elsewhere under the levee to be cut close to the ground. The material for the bank to be earth, free from grass, weeds, roots and all other perishable matter. Berms to be about fifteen feet wide outside and from ten to thirty feet wide inside. The material to be taken from the outside, and berm banks left across the borrow pits every one hundred and fifty feet to prevent a current along the berm of the levee. The cross section of the bank to be a crown at least five feet wide. an outside slope of three to one, and an inside slope of ten to one, the slopes and crown width to be varied according to material used and the height of the bank. Along the berm on the inside a seepage ditch is usually excavated, which extends to some slough or other low ground, where the water may have a channel to the Sny. The average height of the levee is about seven feet and a half. The key levee which crosses the Sny at the head of the district is twenty-eight feet high, twelve feet wide at the crown, with slopes of four to one and three to one with the river slope protected from the current by brush work and willow fascines thatched upon the slope.

In the location of the levee line the highest ridges near the river were sought, but the cavings and makings of the river banks were carefully studied, and the principal on which they moved and the rate of progress noted with pains, that in no place the embankment might in many years be in danger of being undermined by the abrasion of the banks by the current. Straight lines were obtained as far as was practicable, and, where a rectilinar alignment could not be had, as easy curves were introduced as the ground would permit.

Proposed Water Works at Taunton, Mass.

The city of Taunton, Mass., is about to build Water Works and considerable preliminary legislation looking thereto has been effected, the grant having been made about a year ago and the issuing of $200,000 in bonds to commence the construction of the works authorized. The source of supply will probably be from either the Taunton river or Middleboro' pond, the latter being the source of the river in the adjacent town of Middleboro'.

Messrs P. I. Perrin and M. M. Rhodes, the new water commissioners of Taunton, were in this city last week on a tour of inspection, and held a conference with Engineer Chesbrough. It is probable that the new works will be built upon the direct pumping system and will be commenced within the next sixty days.

Newton's Hydraulic Dredge.

We are able to present to our readers, and specially to engineers, a general description of this novel and powerful dredge, which has just been completed and practically tested in this city at the yard of Mr. O. B. Green on the north branch of the Chicago River.

For the very important result that seems to have been attained, we are indebted to the professional skill and inventive genius of Mr. Wm. H. Newton, a civil engineer of much experience, whose efforts have been aided by the practical knowledge of Mr. Green, who is well known as a contractor for dredging and general public works.

This dredge appears to solve the problem so long desired, of an efficient and cheap mode of dredging that must prove of great value ; combining as it does, strength simplicity, efficiency and economy of operation and repairs, with capacity to raise and convey by one operation far in excess of the most costly dredgees now in use.

The present dredge has been constructed by these gentlemen after a season's experience in the working of an experimental dredge to guide them, and the result may be accepted as an accomplished fact of great interest to engineers.

The hull is a model of strength, seaworthiness and durability, as it is intended to be towed through the lakes. The machinery was constructed at the Vulcan Iron Works by Supt. Thomas Burgess, and is massive and symmetrical. The proportions of the various parts show that the inventor comprehended the requirements for such service as this dredge is intended.

The principle involved is the combined action of two or more hydraulic currents, to excavate and dredge simultaneously, excavating by jets of water discharging under high pressure (produced by force pumps) through nozzles against and underneath the face of the material or deposit to be removed. This jet discharge is used exclusively to excavate and float the material; undermining it, by excavating and disintegrating the mass through the impact of the discharging jets directly with the deposit; floating and temporarily suspending the excavated material in the surrounding volume of water, by the reaction of the currents produced by the discharging jets, and simultaneously drawing into the open mouth of a supply pipe to two vacuum cylinders alternately by atmospheric pressure, the whole volume of suspended material, elevating it to the required height above the surface of the water to give it the required velocity to discharge it through pipes at any desired height or distance, by gravity or steam pressure. The jet discharged has a rotary motion around its own axis, to give increased efficiency to its floating power in immediate presence of the open mouth piece of the supply or dredging pipe. Simultaneously a transverse longitudinal and circular movement is imparted to the dredge to secure action of the two currents to excavate and elevate without intermission from the face and bottom of the material to be removed. The mouth piece of the dredge pipe and the jets are connected and reversable, thereby presenting them in combined action against the face or bottom to undermine, thus securing the uniform action of the excavating jets in advance of the mouth of the supply pipe. The velocity of the excavating jets discharge, will depend upon the character of the material to be excavated, as it is entirely practicable up to 250 feet per second. The minimum velocity of the volume through the dredge pipe will be 32 feet per second.

The employment of the almost unlimited power of hydraulic currents and atmospheric pressure in combination for the purpose of dredging will be recognised and appreciated, as of great practical utility by all who have given the subject attention.

The large openings to the vacuum cylinders both for supply and discharge, readily pass masses of rock and other material up to 18 inches diameter and by the application of the dredge pipe large boulders may be sunk below the required depth of channel without additional cost.

The estimated amount that can be dredged by this new dredge, as stated by Mr. Newton, and based upon what was done by the experimental dredge, in any material disintegrable by the present jets discharge is 500 cubic yards of measured material each working hour; at an expense for fuel sufficient to evaporate 88 cubic feet of water per hour and the labor of four men in working the dredge.

The economy of this process and machinery will be appreciated, not only in the volume of work performed within a given time and its relative cost as compared with any other mode yet in use, but also in the original outlay for construction, (which will not exceed $10,000) the little liability to serious injury by use and a minimum expense for repairs.

Proposals for Contracts.

BRIDGES.

Notice is hereby given that the Commissioners of Grant County, State of Indiana, will, on Friday, the 5th day of May, 1876 let the contract for the building of a bridge across the Mississinewa River at the point known as "Sutton's Ford." Plans and specifications on file in my office. By order of Board. Jos. W. Stout, *Auditor Grant Co.* Marion, Ill.

Proposals will be received by the Board of Commissioners of Monroe County, Indiana, at the Auditor's office, at Bloomington, until 1 o'clock, Wednesday, April 26th, for the building of stone abutments for bridge, and iron fence around the court-house square. Plans and specifications can be seen at the Auditor's office. Cash payments. James F. Manley, *Auditor Monroe County.*

Commissioners' Office, Cincinnati, Hamilton Co. O.

Sealed proposals will be received at this office until Saturday, April 29th 1876, at 12 o'clock M., for repairing the Superstructure of the California Bridge over the Little Miami River, on the California and New Richmond Turnpike, between Spencer and Anderson townships. Specifications can be seen at this office. Jos. B. Humphreys, *Auditor.*

The Supervisors of the town of Milton will receive proposals until Friday, April 28, at 12 o'clock M., for building a bridge in Road District No. 2, near J. E. Elias' mill, on the road from Roscoe to Mantorville. The materials, with the exception of the iron will be furnished on the ground. The mason and carpenters' work will be let separate or together. The specifications may be seen at the town clerk's office. J. Cramond, *Town Clerk.*

Proposals will be received at the County Clerk's Office, in the city of Galena, Ill., on Friday, the 28th day of April, for the building of a stone bridge near the village of Hanover. Plans and specifications can be seen at the County Clerk's Office in the city of Galena and at the post office in the village of Hanover. William Howarth, Henry Chapman *County Bridge Commissioners.* John L. Phillips, C. N. Hammond, *Commissioners for the Town of Hanover.*

Commissioners' Office, Cincinnati, Hamilton Co. O.

Proposals will be received at this office until Saturday, April 29th, 1876, at 12 o'clock M., for masonry for a bridge across Dry Fork of Whitewater on the new county road leading from New Haven to Venice in Crosby township. Specifications con be seen at this office. Also for a Superstructure at the same place, wood or iron, 140 feet clear span and 18 feet clear roadway. Also, for taking down, removing and rebuilding Superstructure on new abutments. Payments will be made in Hamilton County Bonds bearing interest at 7 per cent. Joseph B. Humphrey, *Auditor.*

Proposals will be received at the office of the Board of Selectmen, Room No. 2, City Hall, New Haven, Conn., until 7½ o'clock Thursday evening, May 4th, 1876, for furnishing the material and constructing an Iron Bridge of one span—100 feet between centers—40 feet roadway in the clear, with a sidewalk on one side 6 feet in the clear, over West river, at the Congress avenue crossing. For the purpose of inviting proposals from iron manufactures and others who have no plans of their own, plans have been prepared for a standard bridge. Bridge companies and contractors may bid on the engineer's plan, or on plans of their own of equal strength and stiffness. Blank forms of proposals, with the necessary bond attached, and any information concerning plans, specifications, etc., will be furnished upon application. No proposals will be received after the time specified, and all proposals that arn not properly filled out will be rejected. The right to reject any or all bids will be reserved. Samuel Johnson, Secretary of Committee of Selectmen of New Haven and Orange.

City Commissioners' Office, Baltimore, March 30, 1876.

Proposals, plans and specifications will be received at this office until Thursday, 27th April, at 12 M., for furnishing the materials, for and construction of an iron trussed bridge over Jones Falls on the line of John Street. The bridge to be composed of of 4 trusses. The outside lines to be 8 feet from center of truss to the line of sidewalk; the intermediate lines to be 16 feet, 8 inches from center to center. The horizontal bracing to consist of cross struts and diagonal rods, at top and bottom cords. Length between masonry, 136 feet; depth of truss, 18 feet; width of roadway, 40 feet; width of sidewalks (each) 13 feet; whole width of bridge from out to out, 66 feet. For full particulars see Baltimore *Gazette*, April 1st. N. B.—Ordinance 43, of March 1875, provides "that it shall be inserted in the contract and to be part thereof, to be secured by the bond given, that the contractor shall have the work for said bridges done at the city of Baltimore, by mechanics and workmen who are citizens of Baltimore city, and the work to be done, and all the materials that can be furnishad by Baltimore contractors." John E. Toole, *Clerk to City Commissioners.*

BUILDINGS.

Proposals will be received by me for the building of a School House, in York Township, Tama County, Iowa, until Monday, May 1. The specifications can be seen at my office one half mile west of Redman. Amos Rogers, Irving, Iowa, *Secretary of School District.*

Proposals for the erection of a Brick School House in the Independent School District of Hastings, Mills County, Iowa, will be received by the undersigned at his residence in the said district, where plans and specifications may be seen until 2 o'clock in the afternoon of May 13th, 1876. A. P. Provost, Secretary Board of Directors, Hastings, Iowa.

The building of a brick school house 44 x 26 feet, two stories high, in the village of New Boston, Michigan, will be let to the lowest responsible bidder, May 1st, 1876, at 1 o'clock p. m. Plans and specifications at Chester Maes', New Boston. Chester Maes, Samuel Scott, Wm. Hubner, Building Committee

Proposals for the erection of a School House in the Independent District of Flint River Township, County of Des Moines, State of Iowa, will be received by the undersigned, at his office, in said school district, until the 29th day of April, at 1 o'clock P. M. John H. Sudbrack, *Secretary of the Board of Directors.*

Proposals will be received by the undersigned, Trustee of Green township, Morgan County, Ind., until the 1st day of May for the purpose of erecting a Brick School House in said township, according to specifications now in his posession. Terms of payments made known on application. W. C. Cain, Martinsville *Trustee of Green Township.*

Proposals will be received until the 1st of May by the Secretary of Laurel Hill Independent School District, Greenfield township, (P. O. address Martelle,) for building and completing a school house in said district. Plans and specifications can be seen at the *Eureka* office, Anamosa, Iowa, and at Dr. Belden's store, Martelle. S. C. Kemp, *Secretary.*

Martelle, March 29, 1876.

Proposals will be received at the German Lutheran parsonage, No. 213 High street, Akron, Ohio, until 12 m., May 8th, 1876, for furnishing material and constructing a church edifice, complete in all respects in accordance with the plans and specifications. Plans and specifications may be seen and instructions given at the office of Mr. Frank Lukesh, in Cramer & May's Block, on and after April 17th, 1876. W. Hagemann, G. Haas, F. Manthey, Trustees of German Lutheran Church.

Proposals will be received until first Monday in May, 1876, by School Board at Ogallala, Keith County, Nebraska, for building a School House at Ogallala. Plans and specifications can be seen at Ogallala or sent to bidders by application to L. Aufdengarten, Ogallala. L. Aufdengarten, Chairman.

Proposals for the erection of a Court House for Harrison county, Iowa, accompanied by plans and specifications of same will be received by the Board of Supervisors, at the office of the undersigned, in Logan, Iowa, until 12 o'clock, M., of April 27th, 1876. No plans and specifications will be received which are not accompanied with a bid to erect the same. For particulars in regard to estimate, completion and acceptance inquire of the undersigned. W. H. Eaton, Auditor.

Proposals will be received by the Trustees of the State Charitable Institutions at the Blind Asylum in Wyandotte, Kansas, until Friday, April 28th, 1876, at 10 o'clock, P. M., for furnishing the material and constructing a two story brick building with stone basement, about 20 x 40 feet, with tin roof, also including plumbing and excavation. Proposals will be received for doing any portion of the said building, by separate contract. The plans and specifications will be shown at the Blind Asylum, by Supt. Miller, on and after April 17th, 1876. By order Board Trustees, T. T. Taylor, Presdent, W. B. Slosson, Secretary.

The Board of Education of Ottawa will receive sealed proposals for the rebuilding of the Third Ward School House of Ottawa, until the 25th day of April, at 7½ o'clock P. M. of said day. Reasonable bonds will be required for the performance of the contract. Proposals to be handed to the said Board of Education by the bidder in person at the above stated date and hour, at the City Hall, Ottawa. Plans and specifications can be seen at the office of H. C. Furness, Architect, after the 18th of the month. By order of the Board. O. O. Wakefield, Theo. Horn, Joseph Megaffin, Building Committee.

Proposals will be received at Pontiac, Ills., by the Board of Trustees of the Illinois State Reform School up to 4 o'clock P. M. of Thursday, May 14, 1876, for the erection of one family building, to accommodate fifty boys, in accordance with the plans and specifications to be seen at the bank of Joseph F. Culver & Co., Pontiac, Ills. Bids must be accompanied by a bond of $500 binding the successful bidder to enter into a contract, with a bond of $16,000, for the proper completion of the building according to the plans and specifications. O. Huse, Solon Kendall, Jos. F. Culver, Trustees.

Bids will be received at Troy by Wm. A. Woodson, clerk of the County Court of Lincoln County, Missouri, for building a Jail, according to plans and specifications on file in his office, until and including May 8th, 1876. Each bidder to present at said time or before, a certified check, payable to the order of C. W. Martin, presiding justice of said court, in the sum of $100; all checks to be returned except that of the successful bidder, and his check to be also returned if he enters into bond within fifteen days, with approved security, in the sum of $15,000 for the faithful execution of the contract, according to said plans and specifications; otherwise to be forfeited. The contract is to be awarded to the lowest and best bidder, the court reserving the right to reject any and all bids.

Proposals for the erection of a School House in Sub-District No. 2, and one School House in Sub-District No. 6, in the township of Cedar, in the county of Mitchell, and state of Iowa, will be received by James Temple in Sub-District No. 2, and Ole O. Haugerud in Sub-District No. 6, until 1 o'clock P. M. on Saturday the 6th day of May. Plans and specifications will be seen at Jas. Temple's and Ole O. Haugerud at Osage, Iowa. By order of the *Board of Directors.*

The State House Commissioners will receive proposals until noon of May 4th, 1876, to furnish in place, complete, the metallic cornices, caps and covering of the upper dome, including the lantern, and the ornamentation of the Mansard roof, turrets and dome. Separate bids will be received : first, for the roofing and cornice work; second, for the ornamentation. The plans and specifications of said work may be seen, and printed specifications will be furnished, on application at the office of A. H. Piquenard, Acting Architect, in the new State House. Jacob Bunn, John T. Stuart, Jas. H. Beveridge, *Commissioners.*
Springfield, Ill., April 3d 1876.

Tenders are invited for the building of a Court House in the City of Peoria, for the county of Peoria. Plans and specifications are on file in the office of the County Clerk at Peoria. Proposals must be submitted at or before 2 o'clock in the afternoon of Thursday, 27th day of April, and must be enclosed within the printed specifications, in an envelope sealed and directed to Jno. A. McCoy, Chairman of the Board of Supervisors, Peoria, Illinois, and marked " Proposals for Building Peoria County Court House" with the name of the bidder on the envelope. Plans and specifications may also be seen at the office of Wilcox & Miller Architects of the building, 112 and 114 Randolph Street Chicago. The bids will be opened before the Board of Supervisors on Thursday, April 27th, at 2 o'clock P. M., to which bidders are invited. The Board of Supervisors reserve the right to reject any or all proposals. Jno. A. McCoy, Chairman Building Committee.

MISCELLANEOUS.

Plans and specifications for building a break-water or sea wall on the East end and South side of city of Galveston, Texas, are invited. The sum of $250 will be given for the plans and specifications adopted by the committee to be hereafter appointed on break-water. Plans will be received at the Mayor's office in Galveston, until the 1st day of May proximo, at 12 o'clock M. Wm. Boyd, P. H. Hennessy, Geo. Schneider, Special Committee.

Office Cincinnati, Batavia and Williamsburg Railroad Co., Batavia, Ohio, April 10th, 1876.

Proposals will be received at the office of this company until 10 o'clock A. M., April 24, 1876, for the grading of that portion of the road between Williamsburg and the crossing of the Little Miami river, and also for the cross-ties necessary for that part of the road. Profiles and specifications may be seen at this office. The company reserves the right to reject any or all bids. For detailed information address G. H. Wilbor, Superintendent of Construction, Batavia, O. S. Woodward, President.

Sealed proposals, marked "Tender for Grading, etc.," "Tender for Fencing," "Tenders for Ties," and addressed to the undersigned, for sections 1, 2, 3, 4, 5, 6, 7, 8, and 9, Hamilton to Georgetown, (separate tenders for each section) will be received at the Company's Offices, No. 33 Main Street, Hamilton, Ontario, up to Thursday, the 27th April, 1876, at noon. Tenders for grading, etc., to include all clearing, grubbing, close cutting and supplying timber for building culverts, and cattle guards. Plans and specifications can been seen, and forms of tenders obtained, at the Company's offices, on and after Monday, the 17th April. The lowest of any tender not necessarily accepted. On behalf of the Railway Construction Company. Maitland Young, Secretary.

Proposals will be received at the office of the City Clerk of Columbus, Ohio, until Saturday, April 29th, at 12 o'clock, noon, for laying an Asphalt pavement on North High street, from Naghten street to the north corporation line, in acordance with plans and specifications on file in the City Engineer's office, in Columbus. Said pavement will contain 50,000 yards, more or less, and shall be bid for by the square yard. Also, for furnishing and setting curb on North High street. Curb to be not less than five inches thick, eighteen inches deep and three feet in length, dressed on top, face and sides, joints to be dressed eight inches deep. Curb to be either Berea, Amherst or Sunbury stone. Bidders must specify the kind of stone they propose to furnish. H. M. Neil, Secretary.

The City Council of the city of Peoria, Ills. invite bids, to be accompanied with plans and specifications, for the erection of a filter bed at the water works. Bidders will state the plan of filtration proposed, the size and shape of bed, and nature of materials they propose to use. Bids to be left with the city clerk on or before May 24, 1876. Chas. H. Kellogg, Thos. J. Kelly, John P. Cress, Water Works Committee.

Iowa State Agricultural College,
Ames, Iowa, April 6th.

Proposals for putting in steam heating apparatus in the College Building—said proposals to include all labor and material connected with the putting in of said apparatus except the engine house—will be received by the Secretary of the Board of Trustees on or prior to May 1st. All bidders are required to furnish plans and specifications to accompany each bid. E. W. Stanton, *Secretary*.

Proposals will be received at the office of the City Clerk, in Columbus, Ohio, until Monday, May 15, 1876, at 12 o'clock noon, for furnishing materials and doing the following work, to-wit: For building an eighteen inch pipe sewer in Myrtle alley from Broad street to Almond alley. For grading and graveling Fifth avenue; from Summit street to the east corporation line. For grading and bouldering Spring street, from High street to Front street; with Ohio river or bank boulders. For contructing a brick sewer in Town street, from Fair alley to the Scioto river, of the following dimensions: Two feet from Fair alley to Front street, and two and a half feet from Front street to the river. Josiah Kinnear, City Civil Engineer.

Tenders are invited by the Grand Trunk Railway for the purchase of Old Iron Rails, delivered as follows: About 7,000 tons at Toronto, Sarnia, Detroit Junction, or Buffalo. About 1,000 tons at Montreal, or Point Levi,(opposite Quebec). About 3,000 tons at Portland. The company has wharfage accommodation for shipment by water at Toronto, Sarnia, and Portland, and deliveries would be made commencing with May, and extending through the summer. Offers stating the price per ton (of 2,240 lbs.), and the place of delivery, will be received by the undersigned at Montreal, Canada, up to the 15th of May. Joseph Hickson, General Manager.

Notice is hereby given that $12,800, to be paid in State Swamp Lands of the Lower Peninsula, have been appropriated by the Board of Control, to be used in improving the Inland Waters of Antrim and Kalkaska Counties, by Dredging and other means. The job for making said improvements will be let to the lowest bidder or bidders, on Monday, May 1st, 1876, at the Harsha House in Elk Rapids, Michigan, at 1 o'clock P. M. Sealed proposals for doing said work will be received by the undersigned until 12 o'clock noon of said day. Payment for said work will be made in State swamp lands, according to law. Specifications and plans will be exhibited by the undersigned at his residence in Elk Rapids, Mich. Bids must be for the whole work, as shown by the plans, and give the bidder's proposed sureties. The right to reject any and all bids deemed inconsistent with the interests of the State is hereby reserved by the Commissioner. Geo. E. Steele, Local Commissioner.

Proposals will be received at the office of the Board of Improvements, Cleveland, O., until 12 o'clock M., May 15th, for the necessary dredging and other labor in removing bars and obstruction, in the Cuyahoga River, between the Government Pier and Upper Central Way Bridge. Plans and specifications may be seen and blank proposals can be obtained at the office of the City Civil Engineer after May 1st. Each proposal must contain the full name of each person in and making the bid. No proposal will be entertained unless made on the blanks furnished be the engineer,and no proposal will be accepted unless the party or parties making the same shall furnish evidence satisfactory to the Board, that they have the necessary machinery, experience, energy and ability for doing the work, is trustworthy, has sufficient pecuniary resources and is prepared to commence the work within five days after the contract is approved by the council. A bond of $2,000, with surety to be approved by the Board must accompany each proposal that in case the proposal is accepted a contract will be entered into within eight days after the award is made. The right is reserved on the part of the Board, to reject any or all proposals not in accordance with the conditions of this advertisement or that do not conform with the specifications furnished by the engineer. B. F. Morse, City Civil Engineer.

Sealed proposals for water pipes and special castings, indorsed "Proposals for Cast Iron Water Pipes," will be received by the Common Council of the city of Fort Wayne, at the office of city civil engineer, until the 25th day of April, 1876. The person or persons to whom the contract may be awarded, will be required to execute the contract within six days from the date of the award, and give satisfactory security to the common council. The prices must be written in the bid, and also stated in figures. Permission will not be given for the withdrawal of any bid or proposal. Bidders are required to state in their proposals their names and places of residence. Each proposal will be accompanied by the understanding in writing, of two responsible persons, with their respective places of business, or residence, to the effect that if the contract be awarded to the person or persons making the bid, they will, on its being so awarded, become bound as sureties for its faithful performance; and that if he or they shall omit or refuse to execute the same, they will pay to the city of Fort Wayne any damage that may be occasioned to said city by such failure. Bidders will state prices in their proposals, for each separate stem of the pipes and castings to be delivered, by which the bids will be tested. These prices are to cover all the expenses of manufacturing and delivering on the cars in the city of Fort Wayne. An estimate of the work to be done, and by which the bids shall be canvassed, is as follows:

	Pounds.
4,800 feet of 24-inch pipe	1,200,000
3,230 feet of 20-inch pipe	626,620
1,900 feet of 12-inch pipe	165,616
21,750 feet of 8-inch pipe	1,087,500
76,600 feet of 6-inch pipe	2,553,100
5,380 feet of 4-inch pipe	63,000
113,720	5,825,836

These quantities are considered approximate, and the council expressly reserves the right of decreasing the amount such percentage as may be deemed necessary for the benefit of Fort Wayne, and to increase the same such an amount, as in their opinion may be necessary, not exceeding 20 per cent. The council reserves the right to reject any or all bids, should they deem it for the interest of the city of Fort Wayne to do so. John Ryall, City Civil Engineer.

O. B. GREEN, *Pres.* THOS. BURGESS, *Supt.*
C. H. ATKINS, *Sec. and Treas.*

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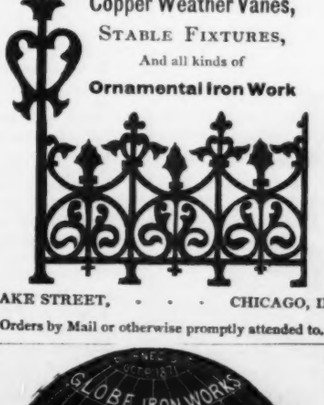

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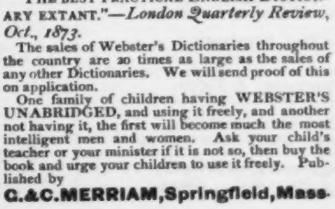

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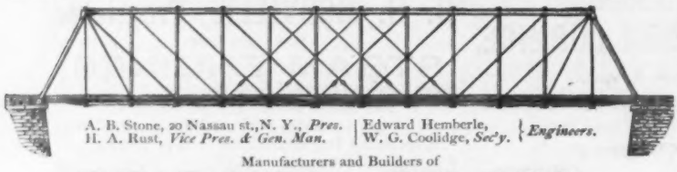

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